

**Application of $^{129}\text{I}/\text{I}$ Ratios
in Groundwater Studies Conducted at
Los Alamos National Laboratory, New Mexico**

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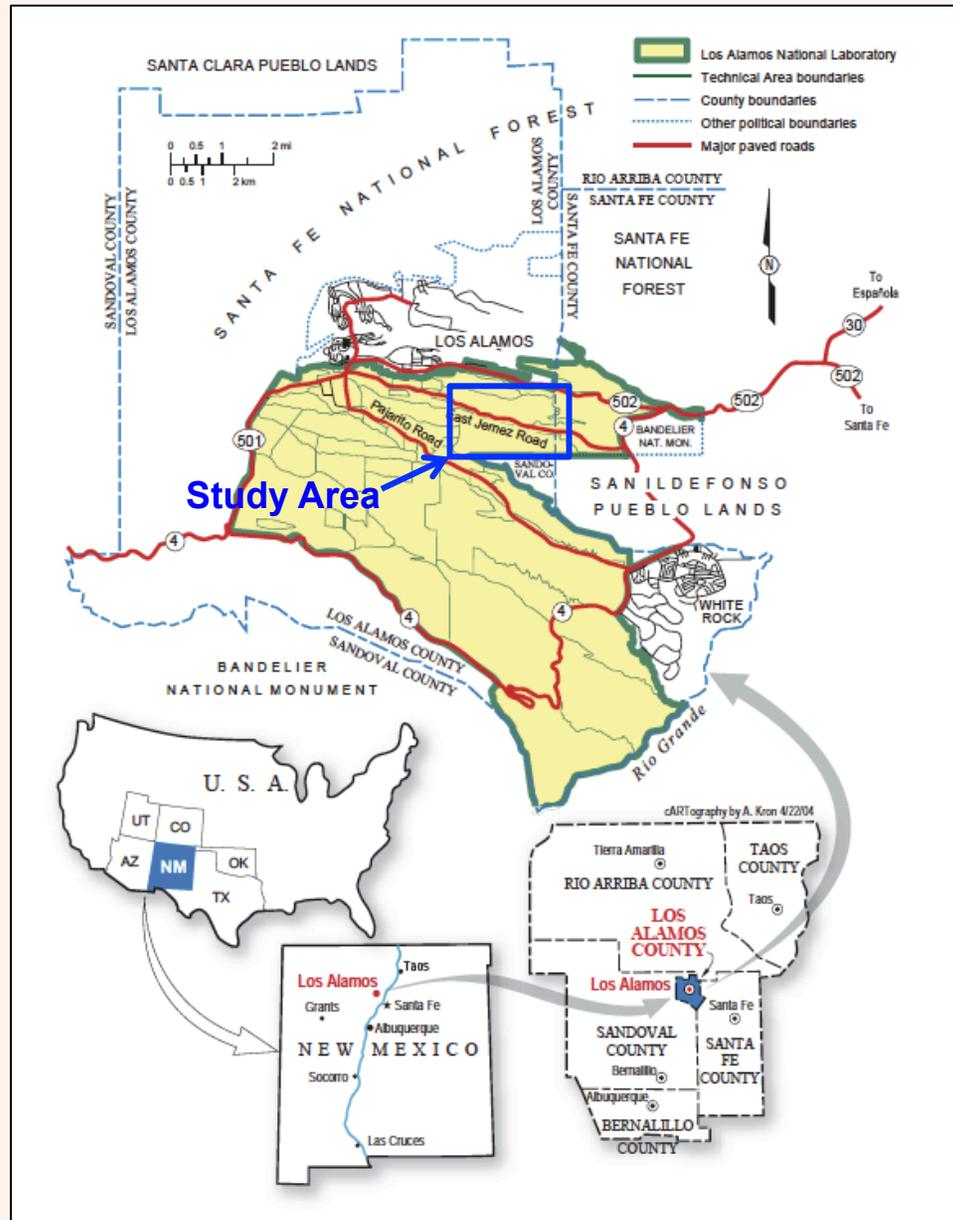
Application of $^{129}\text{I}/\text{I}$ Ratios in Groundwater Studies Conducted at Los Alamos National Laboratory, New Mexico

- **Natural and Anthropogenic Sources of ^{129}I Iodine**
- **Analytical Methods**
- **Hydrogeochemical and Hydrological Setting (groundwater mixing) at LANL**
- **Distribution of ^{129}I and $^{129}\text{I}/\text{I}$ ratios in groundwater**
- **Summary and Conclusions**

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Los Alamos National Laboratory, New Mexico



Source: LANL 2007

Natural and Anthropogenic Sources of ^{129}I Iodine

Natural sources of ^{129}I include cosmic spallation of xenon and fission of uranium occurring in the subsurface.

Fission of uranium releases ^{129}I to groundwater and the atmosphere from volcanic emissions. Residence times for ^{129}I in the atmosphere and oceans are two weeks and 40,000 years, respectively.

Anthropogenic ^{129}I is a fission product of ^{235}U and ^{239}Pu processing at nuclear facilities. Isotope ratios of $^{129}\text{I}/\text{I}$ increased in some parts of the world during the 1960's resulting from atmospheric nuclear testing. Atmospheric $^{129}\text{I}/\text{I}$ ratios ranged from 10^{-7} to 10^{-4} in the past.

Analytical Methods

¹²⁹Iodine and ³⁶Chlorine

Accelerator mass spectrometry

²³⁹Plutonium and Tritium

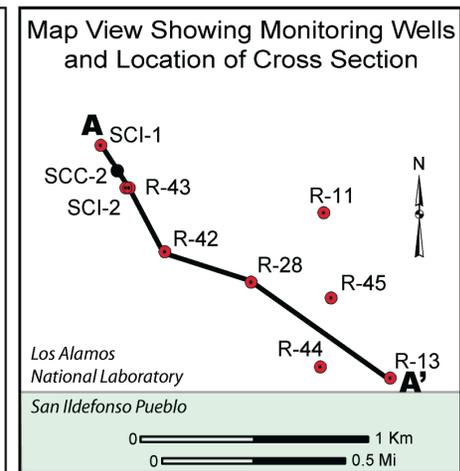
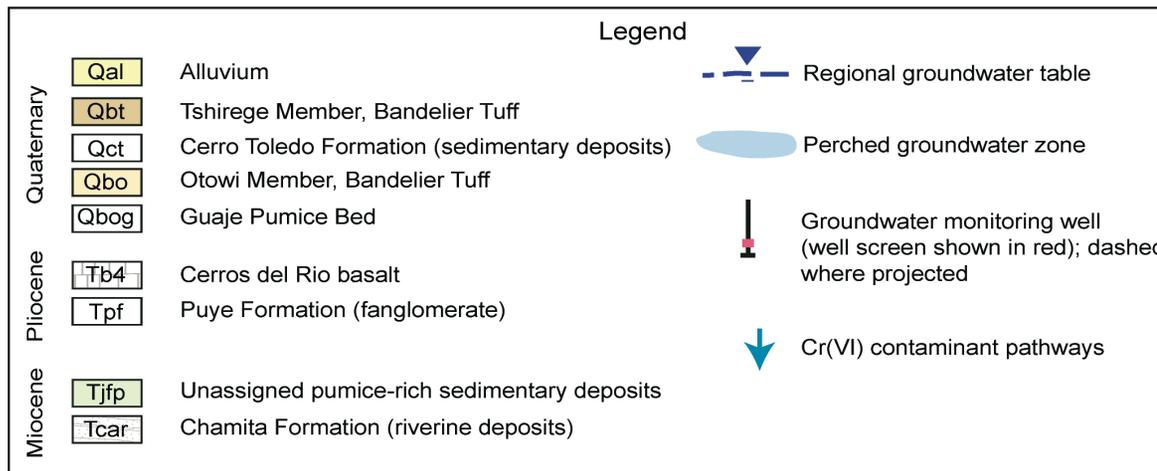
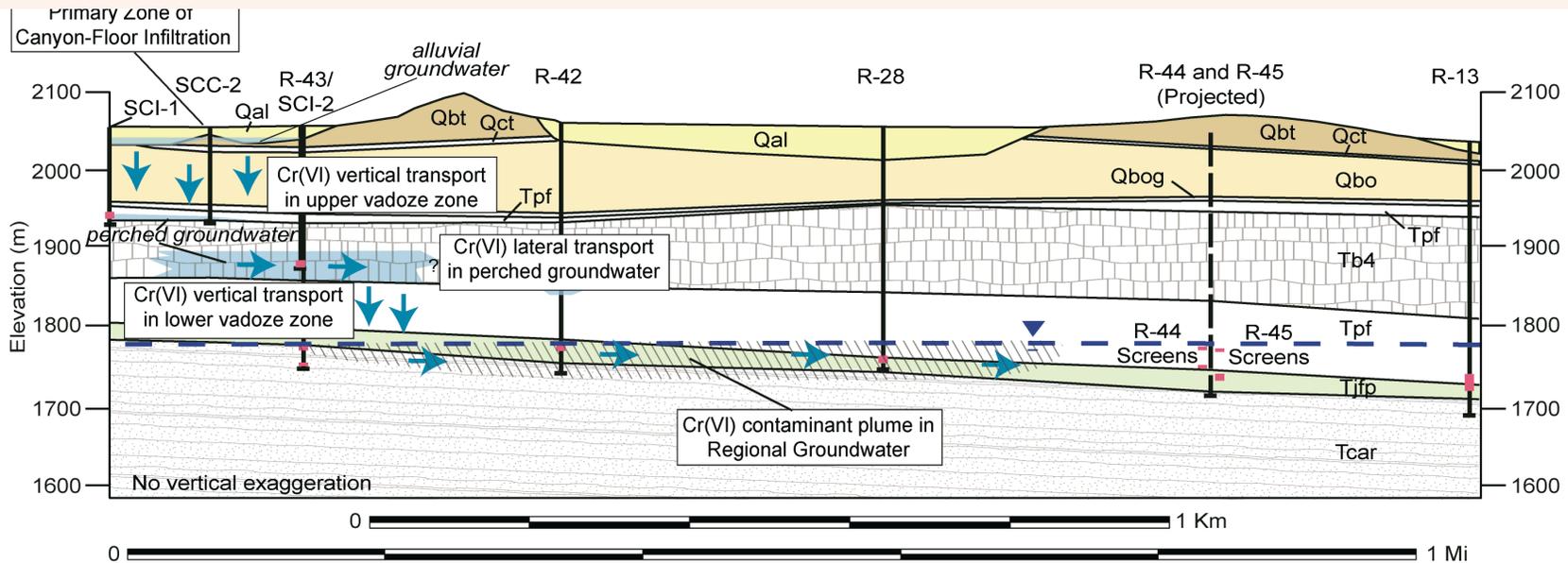
Alpha spectrometry

Electrolytic enrichment and liquid scintillation

Oxyanions

**Liquid chromatography/mass spectrometry-
mass/spectrometry**

Conceptual Model of Groundwater Movement Through the Vadose Zone to the Regional Aquifer, Los Alamos National Laboratory, New Mexico



Source: LANL 2012

Elevated $^{129}\text{I}/\text{I}$ Ratios, ^3H , and/or Cr(VI) Concentrations In Perched-Intermediate Depth Groundwater Zones

Sources of ^3H , ^{129}I ,
 ^{235}U , ^{239}Pu , Cr(VI)

Source of ^3H ,
 ^{129}I , and ^{239}Pu

Elevated $^{129}\text{I}/\text{I}$ ratios,
 ^3H , and/or Cr(VI)

Groundwater-Flow
Paths in Perched
Intermediate Depth
Groundwater



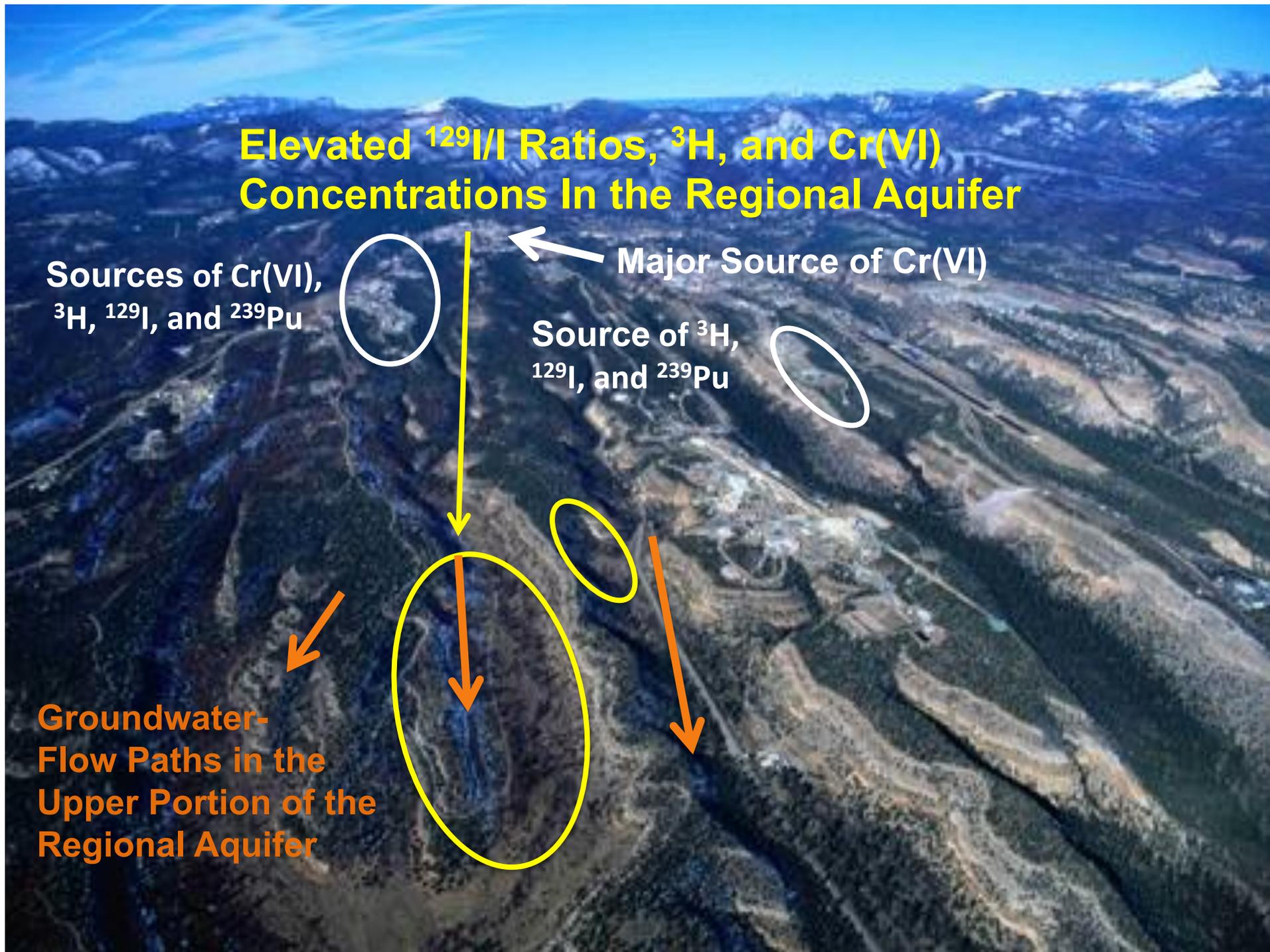
Elevated $^{129}\text{I}/\text{I}$ Ratios, ^3H , and $\text{Cr}(\text{VI})$ Concentrations In the Regional Aquifer

Sources of $\text{Cr}(\text{VI})$,
 ^3H , ^{129}I , and ^{239}Pu

Major Source of $\text{Cr}(\text{VI})$

Source of ^3H ,
 ^{129}I , and ^{239}Pu

Groundwater-
Flow Paths in the
Upper Portion of the
Regional Aquifer



Distributions of Radionuclides in Corehole MCB-5, Mortandad Canyon, New Mexico

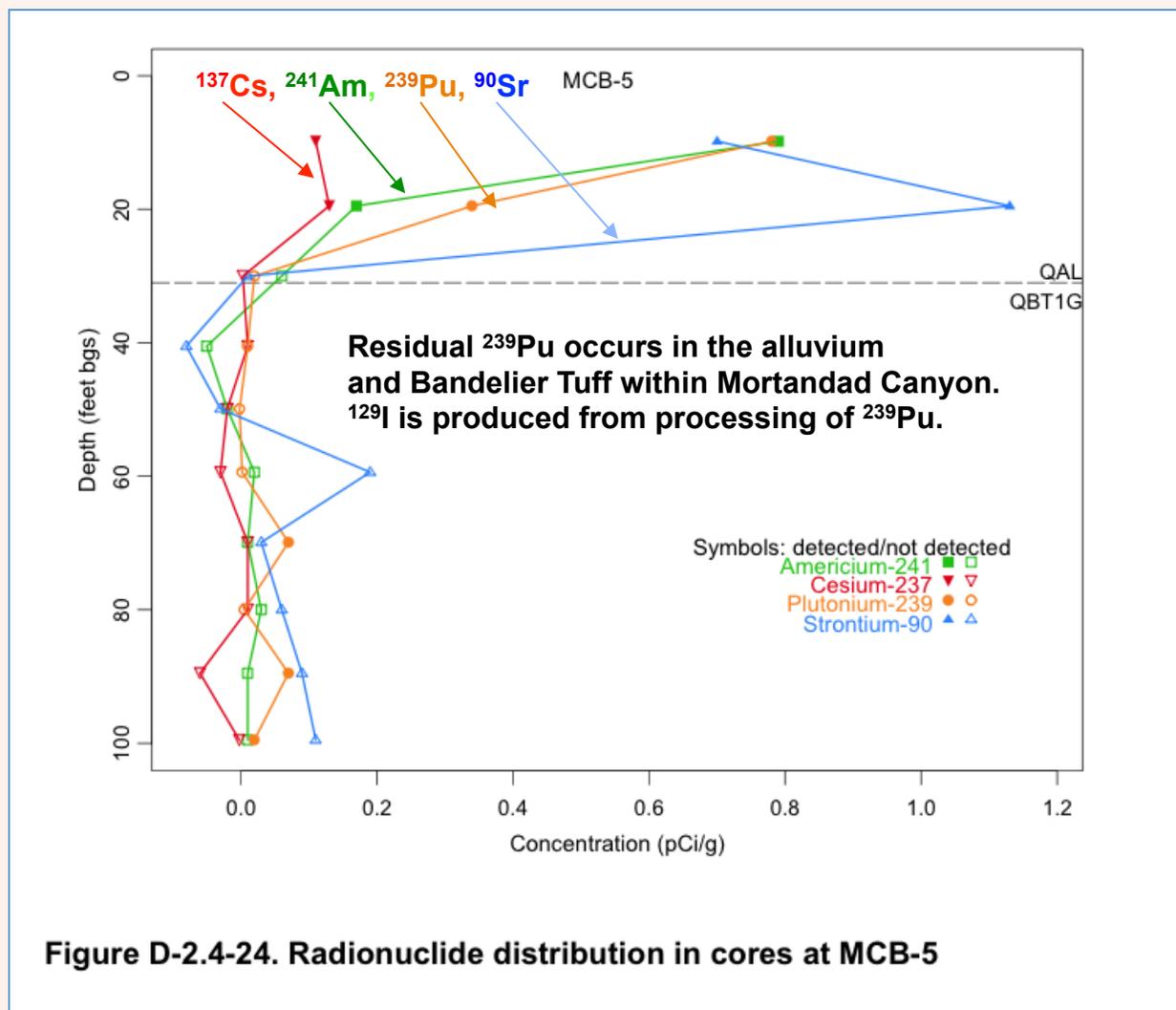
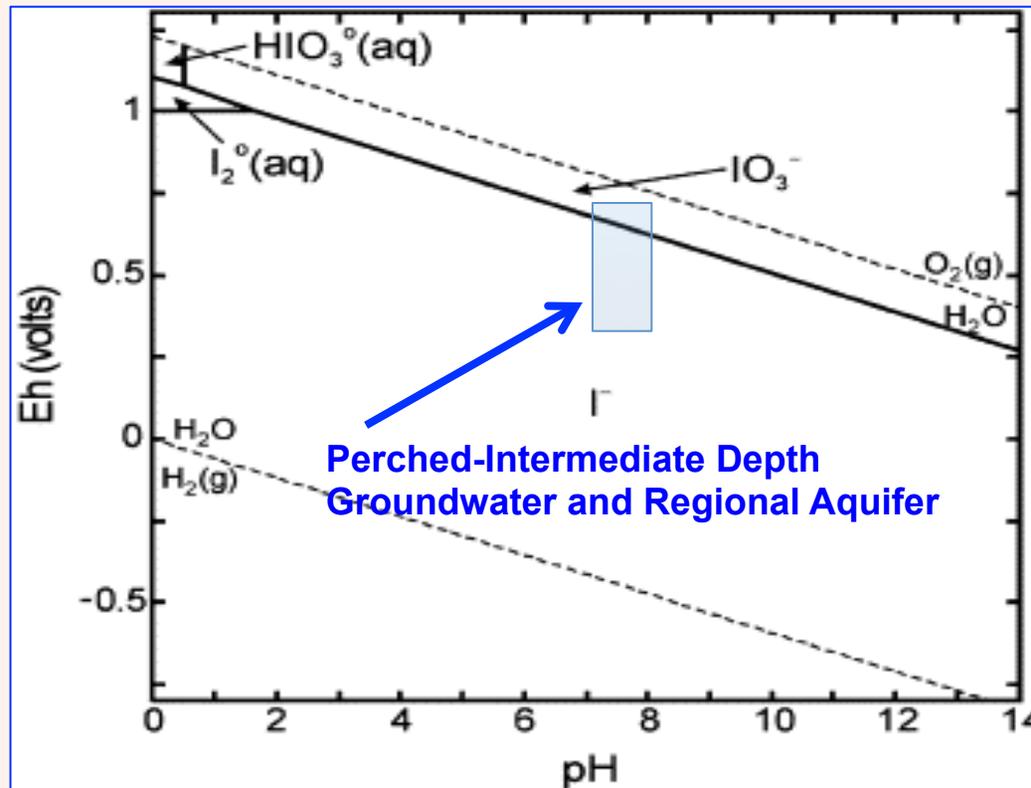


Figure D-2.4-24. Radionuclide distribution in cores at MCB-5

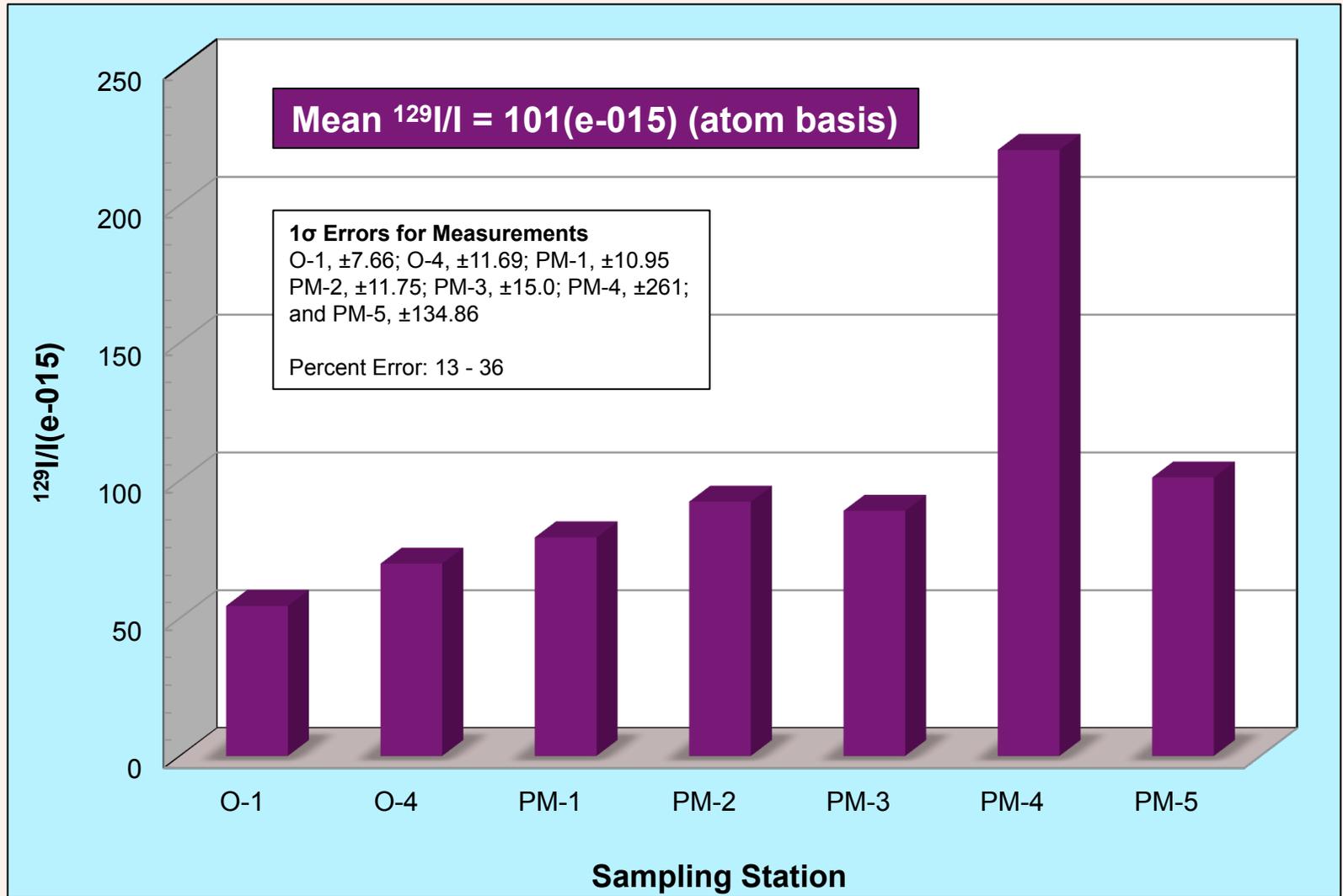
Source: Los Alamos National Laboratory, 2006, Mortandad Canyon Investigation Report, Environmental Restoration Project: Los Alamos National Laboratory, LA-UR-06-6752.

Eh-pH Diagram for Iodine at 25°C and 1 Bar

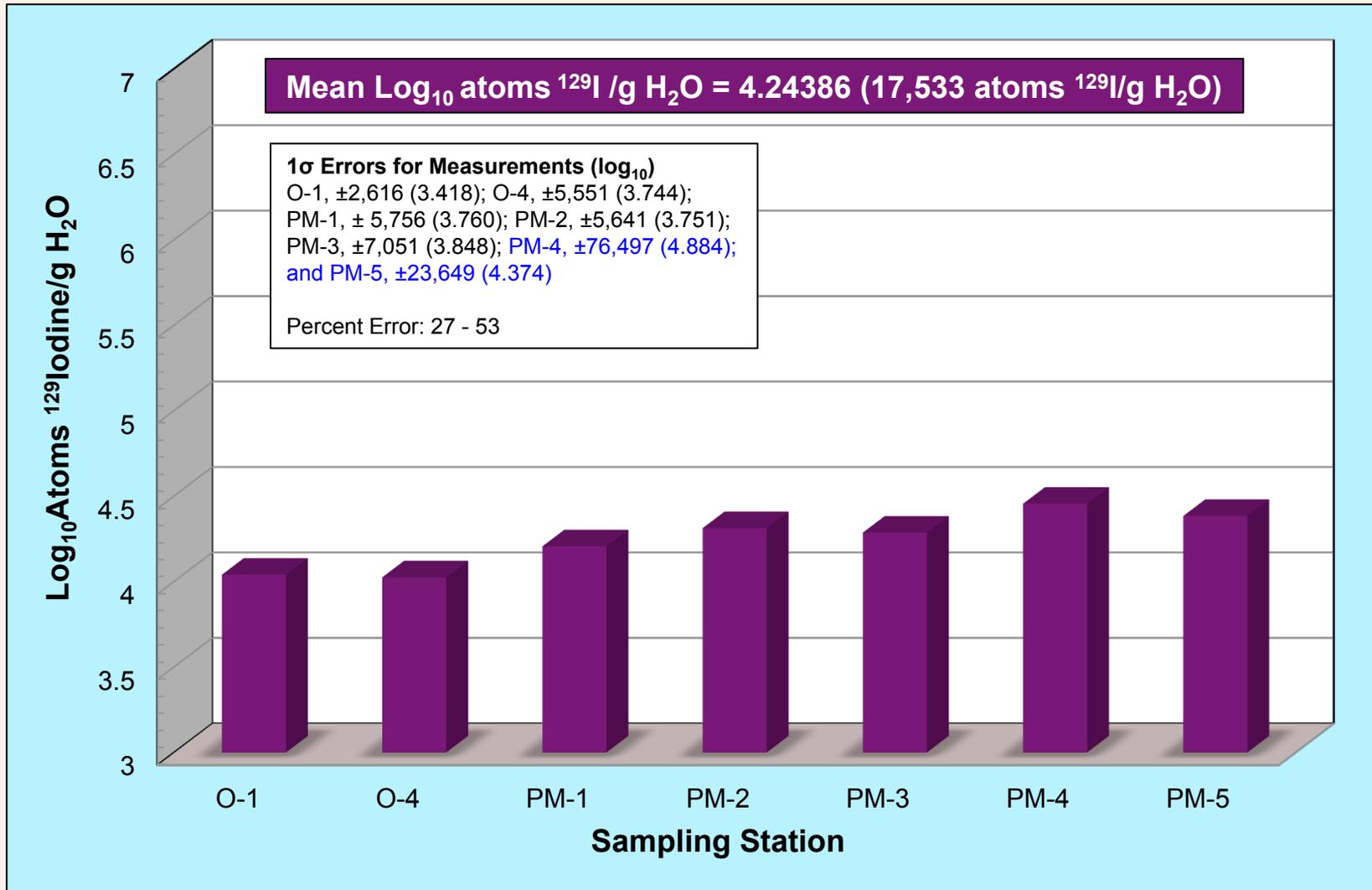
(Total dissolved I concentration = 10^{-8} mol/L. Source: Um et al., 2004)



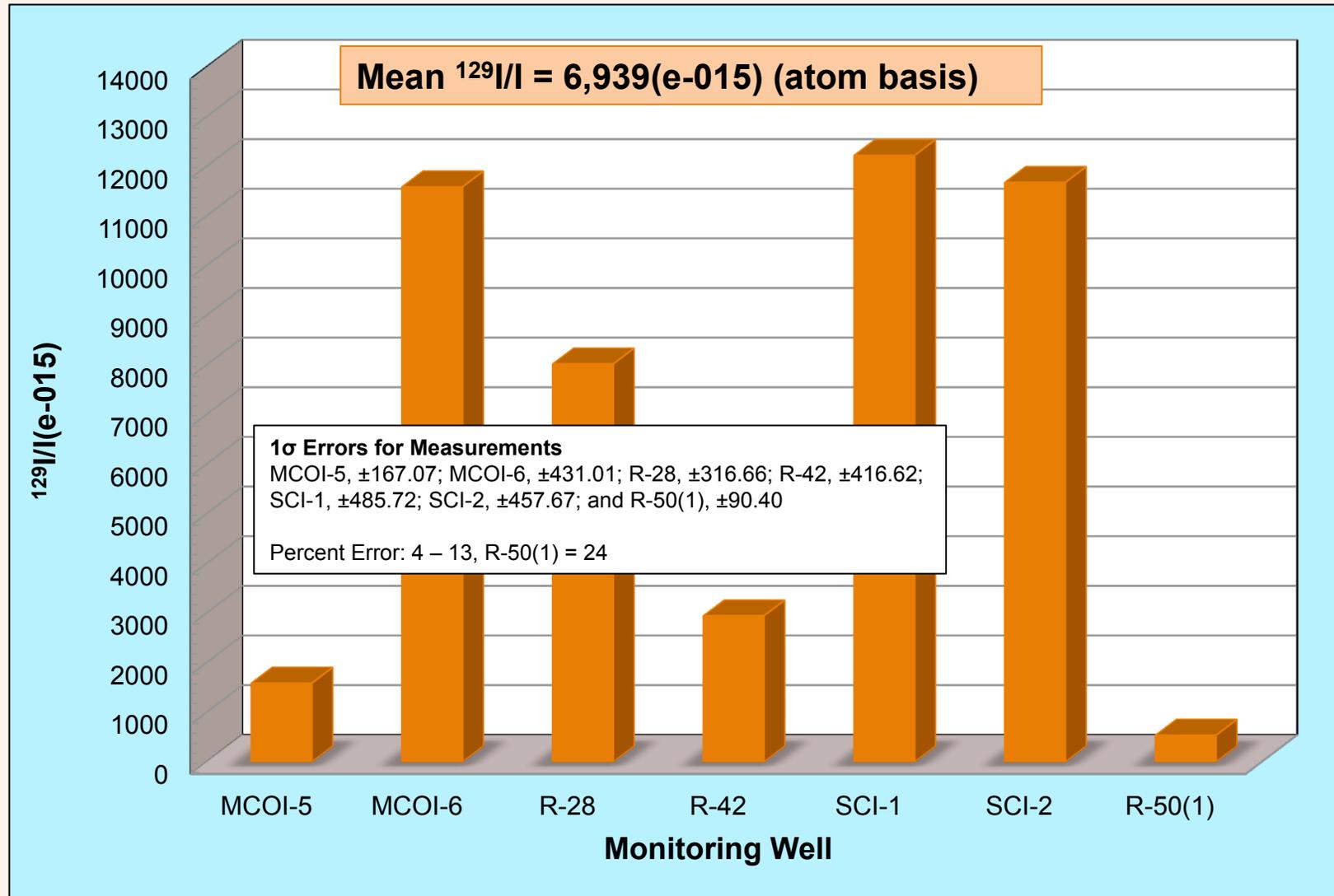
$^{129}\text{I}/\text{I}$ Ratios in Los Alamos County Supply Wells, New Mexico



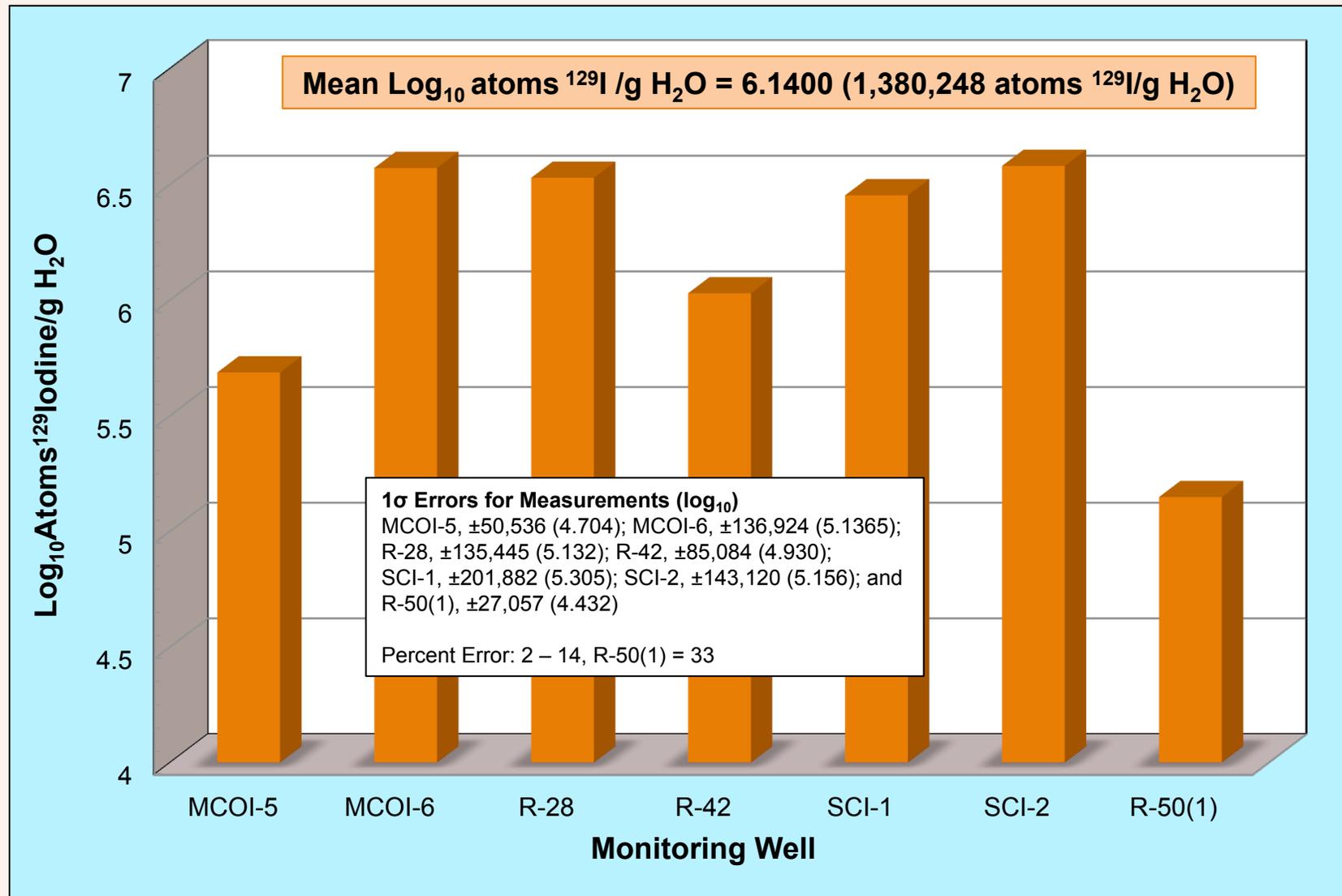
Atoms ^{129}I /g Water in Supply Wells, Los Alamos County, New Mexico



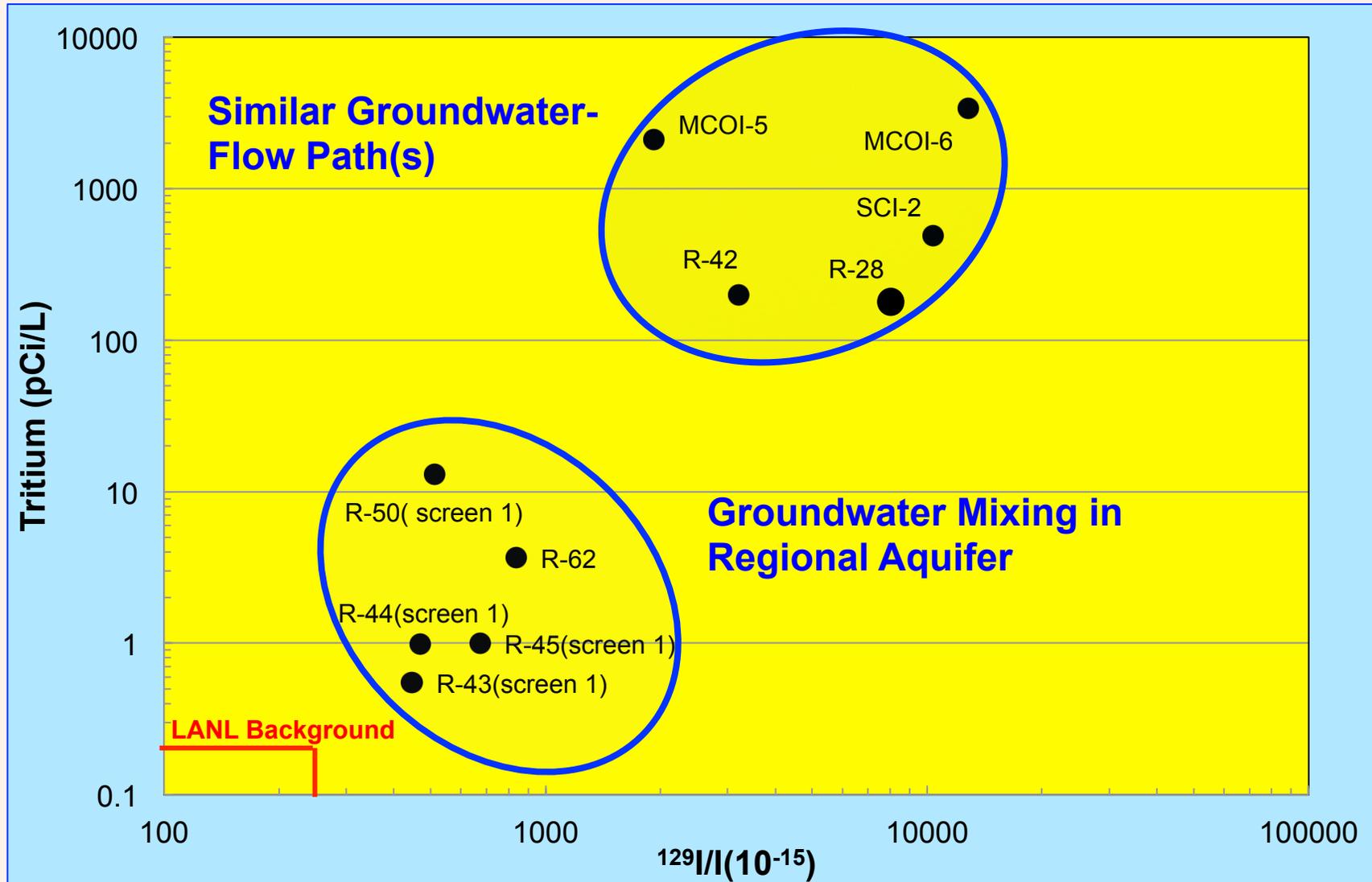
Average $^{129}\text{I}/\text{I}$ Ratios in Selected Monitoring Wells Downgradient From Sources of ^{129}I Iodine, Los Alamos National Laboratory, NM



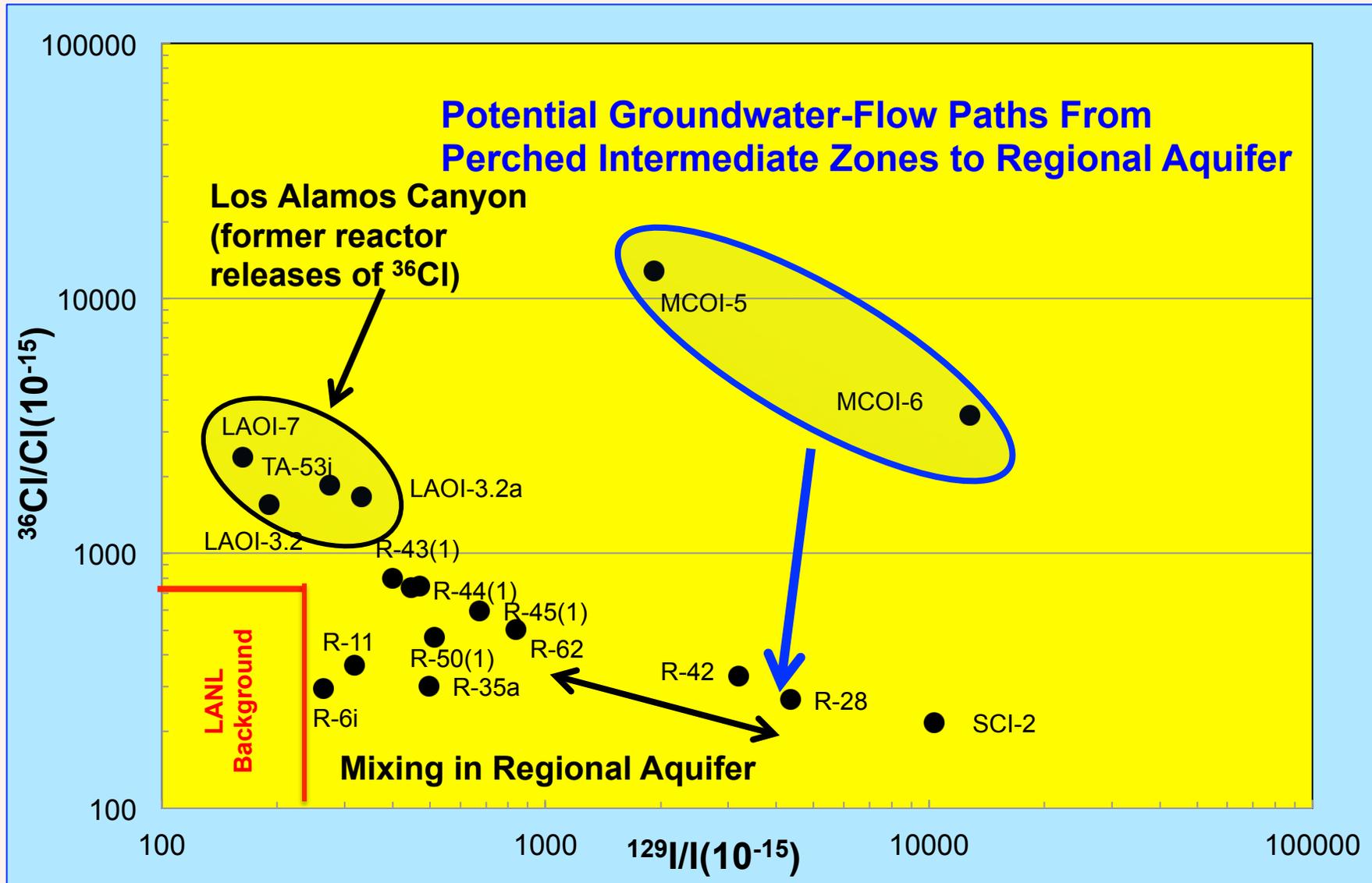
Atoms ^{129}I /g Water in Selected Monitoring Wells Downgradient From Sources of ^{129}I Iodine, Los Alamos National Laboratory, NM



$^{129}\text{I}/\text{I}$ Ratios Versus Tritium in Groundwater, Los Alamos National Laboratory, New Mexico



$^{129}\text{I}/\text{I}$ Ratios Versus $^{36}\text{Cl}/\text{Cl}$ Ratios in Groundwater, Los Alamos National Laboratory, New Mexico



Summary and Conclusions

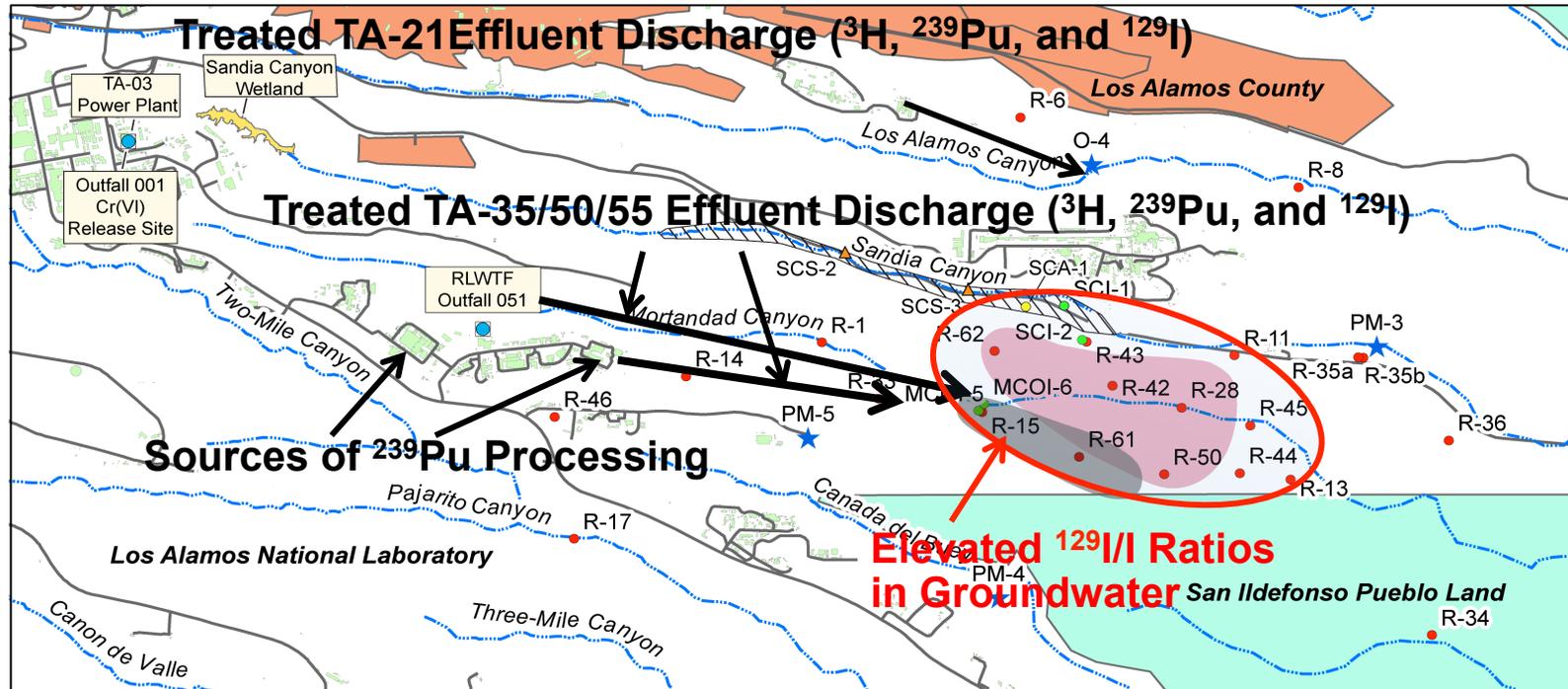
- The radioisotope ^{129}I ($T_{1/2} = 15.7$ Myrs) derived from ^{235}U and ^{239}Pu processing at Los Alamos National Laboratory is locally detected in groundwater above background ^{129}I activities.
- This isotope provides a unique tracer for groundwater investigations conducted at LANL that helps to identify source releases linked to groundwater-flow paths in aquifers.
- Aquifer systems are subject to binary and ternary mixing of natural- and industrial-derived waters containing iodate, chromate, and other chemicals.
- Local background ratios of $^{129}\text{I}/\text{I}$ vary from 54×10^{-15} to 220×10^{-15} in the regional aquifer (supply wells).

Summary and Conclusions

- **Anthropogenic ratios of $^{129}\text{I}/\text{I}$ range from $1,252 \times 10^{-15}$ to $17,367 \times 10^{-15}$ within perched-intermediate depth groundwater in Mortandad Canyon.**
- **Anthropogenic ratios of $^{129}\text{I}/\text{I}$ range from $2,690 \times 10^{-15}$ to $11,688 \times 10^{-15}$ within the regional aquifer in Mortandad Canyon (centroid of chromium plume).**
- **Variability in $^{129}\text{I}/\text{I} \times 10^{-15}$ ratios and concentrations of anthropogenic iodate is controlled by non-uniform source releases of this isotope and iodate over time and non-uniform mixing (ternary) of groundwater in different aquifers.**

Supplemental Slides

Plume Map of Total Dissolved Chromium and Elevated Above Background $^{129}\text{I}/\text{I}$ Ratios within the Regional Aquifer, Los Alamos National Laboratory



0 2.5 Km

- Regional monitoring wells
- ★ Municipal water-supply well
- Intermediate monitoring wells
- Alluvial wells
- Cr(VI) release sites (outfalls)
- ▲ Surface water sampling station
- Sandia Canyon Wetland
- ▨ Zone of Infiltration
- Area of chromium concentrations exceeding 50 ppb
- Area of perchlorate concentrations exceeding 4 ppb
- Roads
- Buildings
- Drainages

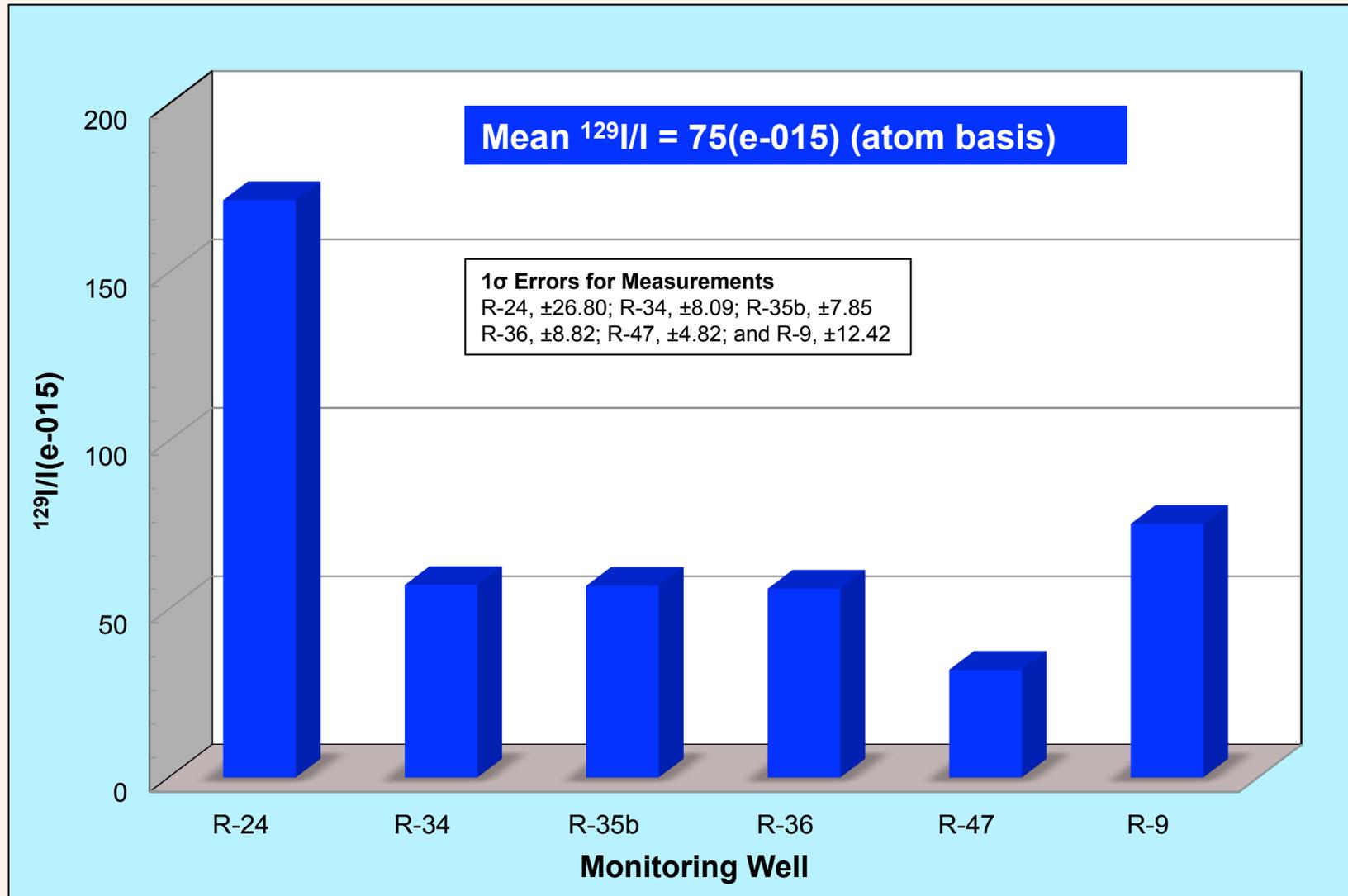


¹²⁹Iodine Yield, Percent Per Fission

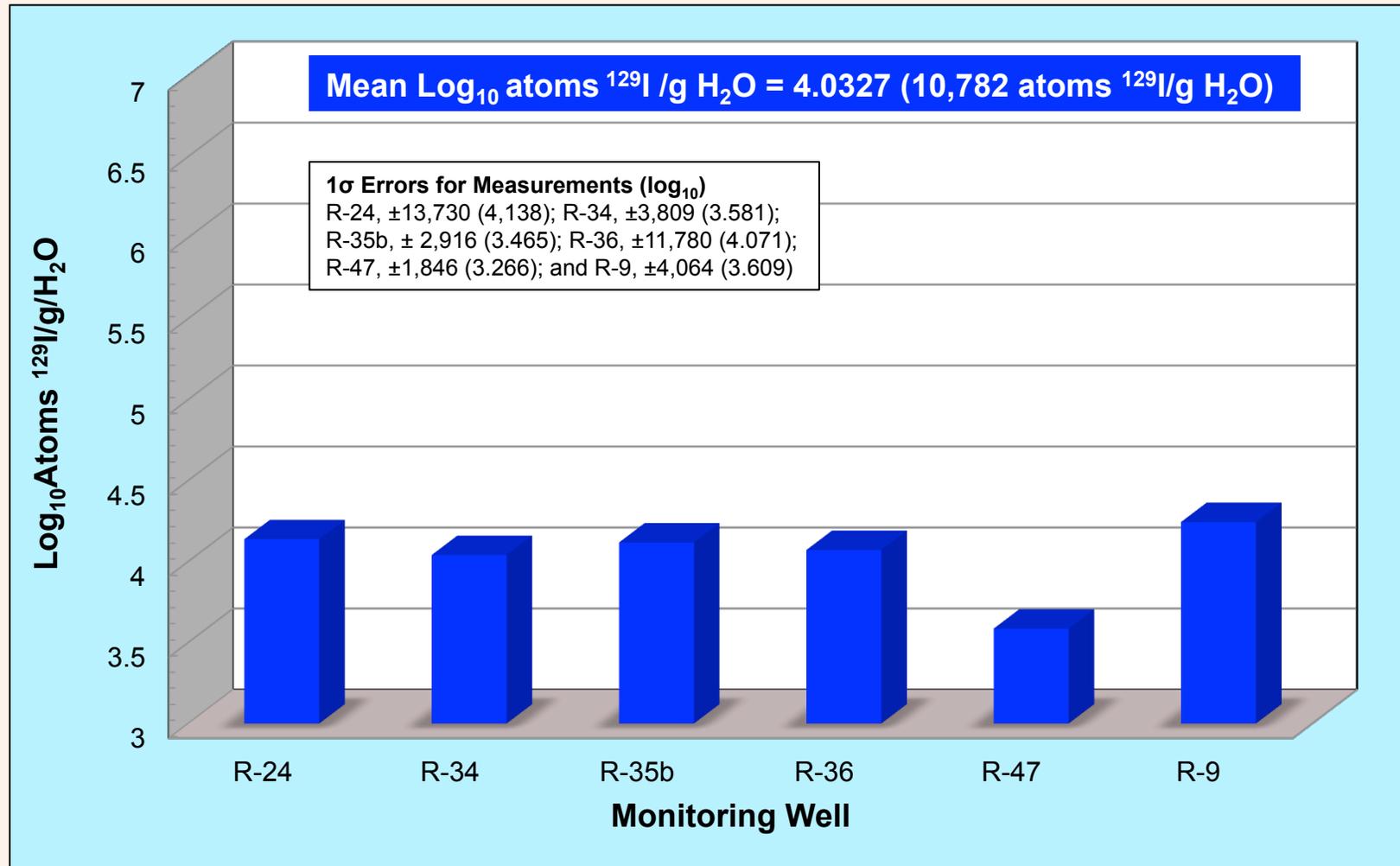
(<http://www-nds.iaea.org/sgnucdat/c3.htm>)

Isotope	Thermal	Fast
²³² Th	not fissile	0.431 ± 0.089
²³³ U	1.63 ± 0.26	1.73 ± 0.24
²³⁵ U	0.706 ± 0.032	1.03 ± 0.26
²³⁸ U	not fissile	0.622 ± 0.034
²³⁹ Pu	1.407 ± 0.086	1.31 ± 0.13
²⁴¹ Pu	1.428 ± 0.36	1.67 ± 0.36

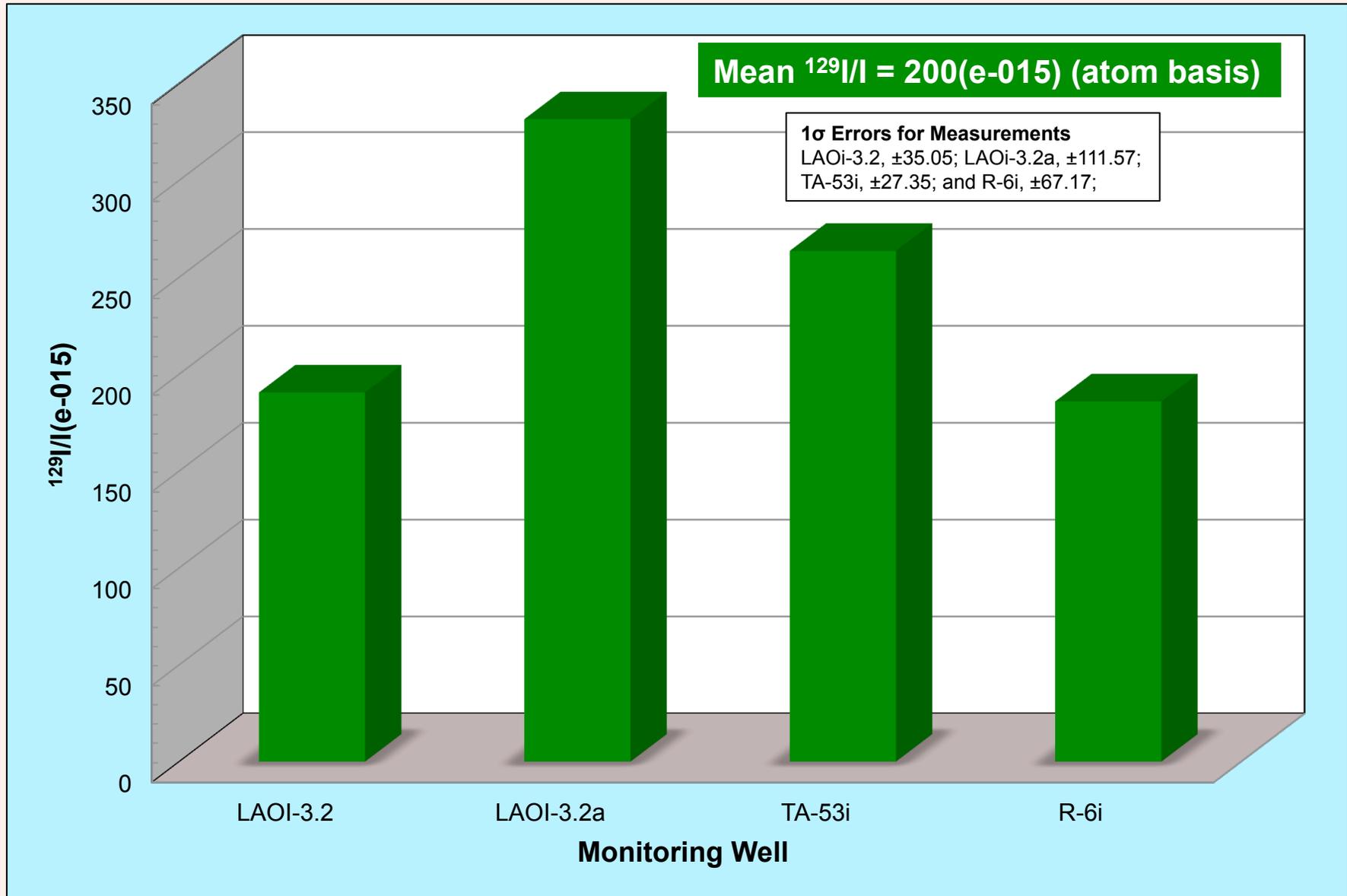
$^{129}\text{I}/\text{I}$ Ratios in Upper Portion of the Regional Aquifer, Los Alamos National Laboratory, New Mexico



Atoms ^{129}I /g Water in the Upper Portion of the Regional Aquifer, Los Alamos National Laboratory, New Mexico



$^{129}\text{I}/\text{I}$ Ratios in Selected Monitoring Wells Near or in Los Alamos Canyon, Los Alamos National Laboratory, New Mexico



Atoms ^{129}I /g Water in Selected Monitoring Wells Near or in Los Alamos Canyon, Los Alamos National Laboratory, New Mexico

